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LIMITS ON TRANSIT TIMING VARIATIONS IN HAT-P-6 AND WASP-1

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The study of Transit Timing Variations (TTV, e.g. Díaz et al. 2008, Sozzetti et al. 2009) is important because it may reveal the effect of other perturbing planets in the exoplanetary systems (Steffen and Agol, 2005), or moons of the transiting exoplanet (e.g. Szabó et al. 2006, Simon et al. 2007, Kipping et al. 2009ab). We present new transit times and Transit Timing Variation analysis of two exoplanets, HAT-P-6b and WASP-1b.

Time series were taken at two different sites. On 19/20 August, 2008, HAT-P-6 was observed with the 0.6 m Schmidt telescope of the Konkoly Observatory, Piszkéstető mountain station. The integration time was 15 s through Johnson R filter. On 3/4 November, 2008, we observed WASP-1 with the 0.4 m telescope of the Szeged Observatory, equipped with an ST-7E CCD camera. The integration time was 30 s through Johnson I filter.

The data were analysed with aperture photometry in IRAF, with an ensemble of comparison stars. Stellar magnitudes were obtained with multiple apertures. The optimal aperture size was determined with minimizing the *rms* scatter of the residuals. In both cases, the aperture radius was 4 pixels, corresponding to 4 arc seconds with the 0.6 m Schmidt and 5.3 arc seconds with the 0.4 m Newtonian. The scatter of the raw light curves is $\approx \pm 0.005$ mag for HAT-P-6 and $\approx \pm 0.008$ mag for WASP-1. After calculating 3-minute averages, these values are reduced to $\approx \pm 0.0025$ mag (HAT-P-6) and $\approx \pm 0.004$ (WASP-1).

Times of minima were determined by fitting a model light curve. To reduce the degree of freedom of fitting, the shape of the model was not adjusted; we used previously published parameters. The model was shifted in time, minimising the *rms* scatter of the measurements.

The log of observations is summarised in Table 1, light curves and TTV diagrams are shown in Fig 1.

Notes on individual exoplanets:

HAT-P-6b is a hot Jupiter known for its very low density. One time of mid-transit at HJD 2454035.67575 $\pm$ 0.00028 was published by Noyes et al (2008), who determined a period of 3.852985 $\pm$ 0.000005 days. They also published a second light curve starting from 2454347.7. We have re-fitted the publicly available photometry simulataneously with our new data by assuming the same transit geometry parameters (duration,

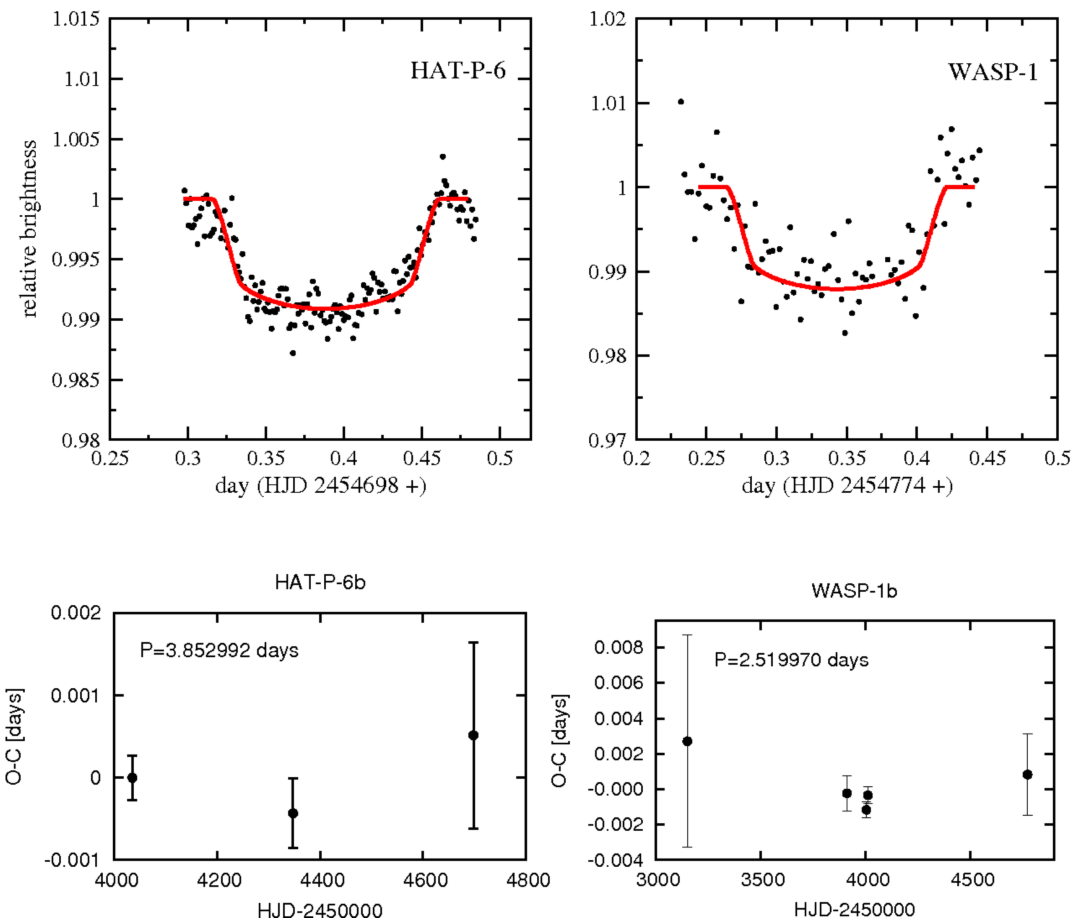

Figure 1. Light curves of the observed transits and fitted models (top panels) and $O - C$ diagrams of the exoplanet systems (bottom panels).

Planet	Date	HJD (first point)	duration (hour)	number of points	transit time HJD−2450000
HAT-P-6b	2008.08.19	2454698.30	4.5	647	4698.3908±0.0011
WASP-1b	2008.11.04	2454774.22	5.2	351	4774.3448±0.0023

Table 1: The log of observations

depth, impact parameter) but independent transit times. The resulted transit times are 2454035.67571±0.00027, 2454347.76763±0.00042 and 2454698.3908±0.0011. The data do not indicate any departure from constant orbital period.

WASP-1b: is supposed to be a hot Jupiter with metal-rich atmosphere, little or no core, and its age is less than 1.5 Gyr. (Cameron et al. 2007, Stempels et al. 2007). Two transits at 2453912.514 ± 0.001 and 2454005.75196 ± 0.00045 were published by Charbonneau et al. (2007), who adopted a period of 2.51997 days. Shporer et al. (2007) published a transit time at 2454013.31269 ± 0.00047 and determined a period of 2.519961±0.000018. Cameron et al. (2007) have also published measurements from 2004 with a pre-discovery transit at 2453151.486 ± 0.006 (the numerical value is available at exoplanet.eu); the resulting period was 2.51995 ± 0.00001 days.

We measured a transit at HJD 2454774.3448±0.0023 and determined a new period of 2.519970±0.000003 days. All transit times are compatible with the updated ephemeris. The pre-discovery transit time is well off a linear fit, but the large error bar preclude any conclusion on TTV. By neglecting this first point, the best-fitting period is 2.519973±0.000003 days and the earliest point is a significant outlier. At this moment it is unclear whether there is period change in the system, hence further monitoring is necessary.

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